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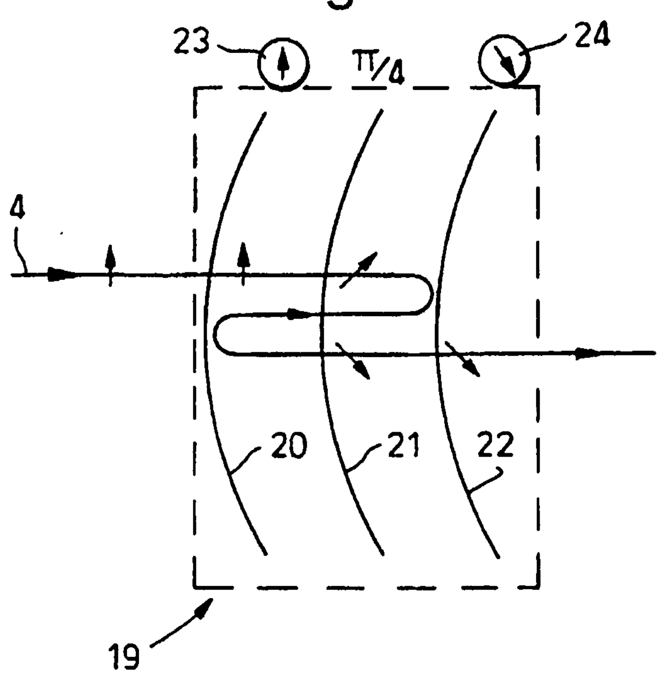
(54) Scanning Apparatus

(57) A reflector lens for selectively transmitting or focussing radiation of different polarisations comprising a first polarising surface, for selectively transmitting and selectively reflecting radiation having a particular direction of polarisation, a second surface for rotating the direction of polarisation of radiation through substantially 45° and a third polarising surface for selectively reflecting and selectively transmitting radiation, wherein the polarisation axis of the third surface makes an angle of substantially 45° with the polarisation axis of the first surface.

Fig.7.



Description

[0001] The invention relates to a reflector lens arrangement, especially as may be used in a scanning apparatus which may be used in a real-time imaging system and, in particular, in a real-time passive millimetre wave imaging system. The scanning apparatus may also be used in other radiometry systems.

[0002] British Patent No. 700868 (February 1952 - December 1953) describes a twistreflector which relates to a similar field as the present invention. International Patent Application WO95/18980 describes a millimetre wave radar system which uses a twist reflector in a folded optics system. Incident radiation of a particular linear polarisation passes through the twist reflector and reflects of a transreflector which rotates the plane of polarisation such that it then reflects from the twist reflector onto a receiver.

[0003] Millimetre wave imaging is potentially useful as an all-weather surveillance and guidance aid but any practically useful system must be capable of imaging in real-time. This is not possible using existing systems. In a millimetre wave imager, radiation from the scene to be scanned is collected by means of a concave mirror or a lens and is focused onto an array of millimetre wave receivers. At present, large two-dimensional arrays of receivers which cover the whole of a required image are not available. Instead, a far smaller number of receivers is scanned across the image in order to build up the complete picture. A similar technique is used in some infrared imagers (for example EP 0226273).

[0004] Current millimetre wave imaging systems use mechanical scanning of one or several channels to synthesise an image. Ultimately, electronic scanning and staring array techniques could be developed to implement real-time millimetre wave imaging, although there are several problems associated with such a solution. Firstly, as the wavelength is necessarily long, in order to image under adverse weather conditions the system aperture must be large to gain adequate resolution. In some millimetre wave imaging systems the input aperture may be of the order of 1 m in diameter. Secondly, the cost per channel is high so that any electronically scanned or staring array technique is expensive. Furthermore, in the case of millimetre wave staring arrays there are fundamental problems analogous to the cold shielding problems encountered in infrared systems.

[0005] Another requirement of a practical millimetre wave imaging system is that it must be able to operate at TV-compatible rates (i.e. 50 Hz for the UK, 60 Hz for the USA). In the infrared, scanning systems are often plane mirrors flapping about an axis contained within their surface. This is not a practical option in the millimetre waveband as large aperture mirrors would be required to flap back and forth at TV-compatible rates, requiring a large change in inertia at the end of each scan.

[0006] In infrared imaging systems, where input apertures are typically only 10 mm in diameter, rotary systems have been used (EP 0226273). Furthermore, in the infrared, it is usual to employ afocal telescopes to match the field of view in the scene to that of the rotating polygon. This is impractical in high resolution millimetre wave imaging where the input apertures have considerably greater diameters and afocal telescopes would need to be excessively large.

[0007] Any scanning mechanism used in a millimetre wave imaging system must therefore be situated in either the object or the image plane. Furthermore, any scanning mechanism situated in the image plane must have good off-axis performance. This is difficult to achieve using existing technology.

[0008] Another known scanning method used in infrared imagers is a system of two discs rotating about axes which are slightly inclined to the normals to their faces. Radiation incident on the first disc is reflected at oblique incidence from the first rotating disc and passes to the second disc to experience a second reflection. By varying the orientation and relative speed of rotation of the discs, varying scan patterns can be achieved. Such a two-axis rotating disc system would not be ideal for use in millimetre wave imaging, however, as the system would be inconveniently large. French patent application FR 2,452,724 discloses an apparatus having two rotating mirrors, each inclined from being normal to the axis of rotation, and a fixed mirror. Radiation is directed from the first mirror to the second mirror via the fixed mirror. Again however the system is not compact.

[0009] It is an object of the present invention to provide a reflector lens arrangement, especially one that can be used in a compact object space scanning apparatus which may be used, in particular, to implement real-time millimetre wave imaging, or in radar systems.

[0010] According to the present invention there is provided a reflector lens for selectively transmitting and focusing radiation having a particular direction of polarisation comprising; a first polarising surface having a first polarisation axis, for selectively transmitting radiation having a polarisation parallel to the first polarisation axis and selectively reflecting radiation having a polarisation orthogonal to the first polarisation axis; a second surface for rotating the direction of polarisation of radiation through substantially 45° and a third polarising surface having a third polarisation axis for selectively reflecting radiation having a polarisation orthogonal to the third polarisation axis and selectively transmitting radiation having a polarisation parallel to the third polarisation axis, wherein the third polarisation axis makes an angle of substantially 45° with the first polarisation axis.

[0011] Preferably at least one of the first, second or third surfaces has a curved surface.

[0012] The reflector lens is arranged such that incident radiation passing through the reflector lens in one direction is focussed by the lens but radiation passing through the reflector lens in the other direction experiences no focussing effect.

[0013] When used to focus radiation to a detector the

first polarising surface may have a substantially flat surface and the third polarising surface may have a substantially spherical surface having a radius of curvature, R, and the apparatus may also comprise a detector array forming part of a spherical surface having half the radius of curvature of the spherical surface of the third polarising surface and being concentric with it.

[0014] The invention will now be described, by example only, with reference to the following figures in which;

Figure 1 shows a diagram of a conventional rotating two axis, two disc system,

Figures 2(a) and 2(b) show examples of the scan patterns which may be achieved using the rotating two disc system in Figure 1,

Figure 3 shows a single axis two disc system,

Figure 4 shows a one disc scanning system comprising a roof reflector,

Figure 5 shows a roof reflector,

Figures 6 shows a compact one disc scanning systems comprising a polarising roof reflector,

Figure 7 shows a schematic diagram of the reflector lens of the present invention,

Figure 8 shows a diagram of a one disc scanning system, including the polarisation sensitive reflector lens of the present invention,

Figure 9 shows a one disc scanning system employing a plurality of roof reflector elements,

Figure 10 shows a near linear open scan pattern,

Figure 11 shows an embodiment of the apparatus which may be used to provide a conical scan pattern and

Figure 12 shows the scan pattern which may be achieved using the apparatus shown in Figure 11.

[0015] Referring to Figure 1, a conventional two disc rotating system comprises two discs 1a,1b, each supported on a separate axis 2a,2b which is connected to a rotor mechanism 3a,3b. Each axis 2a,2b is inclined a few degrees to the normals to the faces of the discs 1a, 1b. Typically the angle of inclination is 5°. As the discs 1a,1b rotate about their respective axes, incident radiation 4 from the scene is incident on the first rotating disc 1a and is reflected at oblique incidence towards the second rotating disc 1b where it experiences a second reflection. From the second rotating disc 1b, radiation may be passed to an imaging or receiving system, typically comprising collection optics 5 and a receiver 6 (or receiver array). For example, the receiver 6 may be the receiver element of a millimetre wave imaging camera or the receiver element of a radar system.

[0016] The two discs 1a,1b may be inclined at the same or different angles to the normal to the respective disc face and may rotate with the same or different speeds, depending on the scan pattern required at the imager. If the two discs 1a,1b are inclined at different angles to their axes of rotation and are rotated at different speeds, a two-dimensional scan pattern will be achieved. If the angles of inclination of the two discs are the same, two discs rotating in the same direction give rise to a petal scan pattern, as shown in Figure 2a. If the angles of inclination of the two discs are the same and the discs rotate at the same speed but in opposite directions an almost linear scan pattern may be achieved, as shown in Figure 2b.

[0017] For operation at millimetre wavelengths the apparatus shown in Figure 1 is required to be large and, furthermore, is rather complex. It is therefore impractical for use at these wavelengths.

[0018] Referring to Figure 3, a compact scanning apparatus, suitable for use in a millimetre wave imaging system, comprises two reflecting plates, for example discs 1a,1b, supported on a single axis 7 passing through the centre of the surface of each disc 1a,1b, a rotary mechanism 3 and a fixed, plane mirror 8. Radiation 4 from the image scene falls onto the first rotating mirror 1a. Any one direction of the incident radiation 4 undergoes a conical scan on reflection and falls onto the plane mirror 8. From the mirror 8 radiation is reflected to the second rotating disc 1b where it is reflected to the collection optics 5 of the imager. From the collection optics, radiation is focused to the receiver element 6 of the imaging system situated in the image plane of the focusing optics 5.

[0019] The normals, n_a,n_b, to the two discs 1a,1b make an angle θ_a,θ_b respectively to the axis of rotation 7. For the configuration shown in Figure 3, where the discs 1a,1b are inclined in opposite directions, the direction of the scan is perpendicular to the plane containing both the axis of rotation 7 and a normal to the plane of the mirror 8. If the two mirrors are tilted in the same direction, rather than in opposite directions, the direction of the scan is in the plane containing both the axis of rotation 7 and a normal to the plane of the mirror 8. Typically, the angles θ_a,θ_b may be between 1° and 10°.

[0020] It is advantageous to have the angles of inclination (θ_a,θ_b) of the rotating discs 1a,1b in the same plane and of substantially the same amount ($\theta_a = \theta_b = \theta$) but in opposite directions. In this case, the forces due to the tilt of the mirrors and their windage cancel on the axis of rotation 7. With the configuration shown in Figure 3, the incident beam of radiation 4 is scanned through an angle of $\pm 4\theta$ (where θ is the angle of inclination of the mirrors to the normal to the axis of rotation 7). Therefore, for example, an inclination of 4° produces a total

field of view of 32° in the scene.

[0021] After radiation 4' has been reflected from the two reflecting discs 1a,1b, it is focused by the collection optics 5 onto the receiver 6 of the imaging system. The receiver 6 may typically be one or more millimetre wave detectors in an array. A temporal encoded form of the image is recorded by the detector or detectors in the image plane and, from a knowledge of the scan pattern, a two dimensional image may be unfolded from the temporal encoded signal or signals.

[0022] For particular disc angular velocities and phases the resulting scan pattern is a raster scan. For reasons associated with the way the eye processes a moving image, a raster scan may be the most desirable form of scan. Furthermore, using a raster scan a linear array of detectors could be used, each detector recording one or several lines in the image. This architecture eases the unfolding of the data to form the required image.

[0023] For example, with the two discs (Figure 3) rotating at the same speed, the resulting scan is a line scan in one dimension. The second dimension in the image may be formed by a linear array of detectors positioned at 90° to the line scan. In this case the number of image pixels in one direction would be the same as the number of detectors.

[0024] In an alternative embodiment of the scanning apparatus, the two rotating discs may be replaced with just one rotating disc 1, as shown in Figure 4, further reducing the size of the entire apparatus. In this configuration, the apparatus also comprises a 90° ($\pi/2$) roof reflector 9.

[0025] The construction of the roof reflector 9 is described with reference to Figure 5. The roof reflector 9 may comprise two flat reflective surfaces 10a,10b which are inclined at substantially 90° to each other and are in contact along an apex 11. In the figure, a hypothetical line 12 is drawn between the two reflective surfaces 10a, 10b, wherein the line 12 is substantially orthogonal to the apex 11. The line 12 shall hereinafter be referred to as the line of intersection of the two surfaces 10a,10b.

[0026] Referring to Figure 4, radiation 4 from the scene is incident on the disc 1 and is reflected to the 90° ($\pi/2$) roof reflector 9 where it reflected back to the rotating disc 1 and then reflected to the collection optics 5 of the imaging system, via a beam splitter 13 which separates the path of incoming and outgoing radiation. Although it is preferable to separate the path of input radiation 4 from the path of output radiation 4', in some operating configurations it may not be essential and the beam splitter 13 may be omitted from the apparatus shown in the Figure 4.

[0027] As in the previous example, the rotating disc is inclined slightly to the normal to the axis of rotation 6 by an angle θ. Typically, the angle of inclination, θ , may be 5°. Using this configuration, an almost linear angular scan (as shown in Figure 2(b)) is achieved in a plane parallel to the line of intersection 12 of the two reflective surfaces 10a,10b.

[0028] Although it is preferable to use a roof reflector in this arrangement, two independent reflective surfaces may also be used, where the two reflective surfaces are inclined such that they are at an angle of substantially 90° to each other but are not necessarily in contact. This arrangement, however, would result in a loss of some radiation reflected from the disc to the reflective surfaces.

[0029] The beam splitter 13 may be a conventional polarising mirror and provides a means of separating output radiation 4', for transmission to the imaging system, from input radiation 4. A conventional polarising mirror typically consists of a flat transparent plastic sheet with closely spaced, thin, parallel conducting wires. If the wires are oriented at an angle of 45° ($\pi/4$) to incident radiation, only 45° linear polarised radiation is transmitted. The parallel conducting wires of the polarising mirror are oriented at an angle of 45° to the incident radiation 4, and therefore only 45° linear polarised radiation therefore propagates to the roof reflector 9. Transmitted radiation is therefore incident at the roof reflector 9 with its polarisation inclined at 45° to the line of intersection 12 of the two reflective surfaces 10a,10b. Radiation 4 experiences a 90° rotation of its direction of polarisation on reflection at the roof reflector 9 and is transmitted to the reflective disc.

[0030] Upon reflection from the rotating disc 1 for this second time radiation is therefore $-\pi/4$ linearly polarised and is subsequently reflected by the polarising mirror 13 and passed to the collection optics 5. The polarising mirror 13 is therefore transparent for incoming radiation polarised in a direction perpendicular to the direction of the conducting wires and is reflective for incoming radiation polarised parallel to the direction of the conducting wires. The arrangement shown in Figure 4 would therefore only allow a single polarisation to be detected at the receiver 6.

[0031] In this embodiment, the rotating disc 1 has to be over-dimensioned compared to the aperture of the collection optics 5, firstly because its axis of rotation is inclined to the direction of the incident and reflected beams and secondly because there is a significant displacement of the beam from its mean position as the mirror rotates about its axis.

[0032] Both of these effects may be overcome by placing the rotating disc 1 close to the roof reflector 9, as shown in Figure 6. As in the previous examples, the normal to the rotating disc 1 is slightly inclined at an angle, θ, to the axis of rotation 7. In this configuration, the scanning apparatus includes a polarising roof reflector 14 comprising two substantially flat polarisers 15a,15b inclined at substantially 90° to each other. The two polarisers 15a,15b take the place of the two reflective surfaces 10a,10b in Figure 5. The polarisers 15a,15b have polarisation axes oriented to transmit radiation having substantially the same polarisation and substantially parallel or perpendicular to the line of intersection 12 of the two polarisers 15a,15b, therefore substantially per-

pendicular or parallel to the apex 11 (see Figure 5). As mentioned previously, it would also be possible to use two independent polarisers in place of the polarising roof reflector, where the two polarisers are inclined at substantially 90° but are not necessarily in contact.

[0033] In this embodiment, the scanning apparatus also comprises a Faraday rotator 16 for rotating the direction of polarisation of radiation by 45° ($\pi/4$). Radiation incident on the Faraday rotator 16 undergoes a rotation in its direction of polarisation each time it passes through (i.e. 45° rotation per pass). Radiation 4 having one particular direction of polarisation is input through the roof reflector 14 to the Faraday rotator 16. Radiation is reflected by the rotating disc 1 and its direction of polarisation is therefore rotated by a further 45° as it is transmitted back through the Faraday rotator 16. The radiation is then reflected at the roof reflector 14 and experiences a further total rotation in its direction of polarisation of 90° as it passes back and forth through the Faraday rotator 16, while being reflected for a second time at the rotating disc 1. At this point, the direction of polarisation is such that radiation 4' is able to pass through the roof reflector 14.

[0034] Alternatively, the Faraday rotator 16 may be replaced with a millimetre wave birefringent surface, such as a Meander-line. For incident plane polarised radiation, which may be resolved into two perpendicular components each oriented at $\pi/4$ (45°) to the direction of polarisation of the incident beam, a meander line may be constructed to introduce a 90° ($\pi/2$) phase shift between the two perpendicular components. A 90° ($\pi/2$) phase shift is therefore introduced in the state of polarisation of radiation each time radiation passes through the Meander-line. Further details relating to Meander-lines may be found in the following references; *L. Young et al., IEEE Transactions on Antennas and Propagation, vol AP-21, pp 376-378, May 1973, and R-S Chu et al., IEEE Transactions on Antennas and Propagation, vol AP-35, No 6, pp 652-661, June 1987.*

[0035] Having passed through the roof reflector 14, plane polarised radiation incident on the Meander-line is therefore circularly polarised. The circularly polarised radiation is reflected from the rotating disc 1 and passes back through the meander line to the polarising roof reflector 14 where it is reflected on the first pass, back through the Meander-line and the reflective disc, but is transmitted on the subsequent pass.

[0036] In practice, a number of Meander-lines may need to be used in a stacked configuration to give the required $\pi/2$ phase shift between the two axes. The Meander-lines may be more suitable for use in millimetre wave imaging at the long wavelength end of the wave band (e.g. 35 GHz).

[0037] The path of output radiation 4' reflected from the scanning apparatus is separated from the input radiation 4 using an inclined flat polariser 17 and an additional 45° Faraday rotator 18. Output radiation 4' is therefore separated from the path of input radiation 4 and is directed to the collection optics 5 of the imaging system. In this configuration, it is essential that the polariser 17 reflects radiation at substantially 45° to the direction of polarisation transmitted by the two polarisers 15a,15b (i.e. at 45° to the apex 11). When using this roof reflector 14 the direction of the scan at the imager is parallel to the line of intersection 12 of the two polarisers 14a,14b of the roof reflector 15. In this configuration, the imaging system will detect a single polarisation state only.

[0038] Although it is preferable to separate the path of input radiation 4 from the path of output radiation 4', in some operating configurations it may not be essential and the polariser 17 and the Faraday rotator 18 may therefore be omitted from the apparatus shown in the Figure 6.

[0039] Figure 8 is a modification of Figure 6 and includes a reflector lens according to the present invention to enable focused radiation to be passed directly to the receiver 6. Figure 7 shows a schematic of the reflector lens 19 which may be included in the scanning apparatus. The reflector lens 19 comprises three elements; two polarising elements 20,22 (alternatively referred to as polarising reflectors) and a Faraday rotator 21 which rotates the plane of polarisation of radiation passing through by 45°. The arrows 23,24 indicate the direction of polarisation of radiation transmitted by the elements 20 and 22 respectively.

[0040] For the purpose of this description, the elements 20,21,22 may also be referred to as surfaces 20,21,22. Although the surfaces 20,21,22 are illustrated in Figure 7 as having curved surfaces, this is not essential. For example, at least one of the surfaces 20,21,22 may have a substantially planar surface.

[0041] The arrows shown along the path of radiation 4 indicate the direction of polarisation as the radiation is transmitted through the reflector lens 19. Radiation 4 is incident on the first element 20 where one direction of polarisation is transmitted (i.e. radiation having a its direction of polarisation vertically in the plane of the paper). Radiation transmitted by the first element 20 passes through the second element 21 which rotates the direction of polarisation by 45°. For example, the second element may be a 45° Faraday rotator. The polarisation of radiation incident at the third element 22 is perpendicular to the polarisation state which is transmitted by the surface 20 and is therefore reflected. On the return path, radiation undergoes a further rotation of 45° in its direction of polarisation as it passes through the second element 21. The direction of polarisation is now perpendicular to the transmission axis of the first element 20 and so the radiation is reflected. The reflected beam undergoes a further rotation of 45° as it passes through the second element 21 and its polarisation is such it is then transmitted, and output from the reflector lens 19, by the third element 22. Hence, the operation of the lens arrangement 19 is such that one polarisation passes through the lens without any focussing effect but when

the same polarisation passes through a second time, on the return path, it is focussed. The non-recipirocal nature of the lens is achieved by using a Faraday rotator inside the arrangement.

[0042] Figure 8 shows the still more compact scanning apparatus, including the reflector lens 19 shown in Figure 7. The reflector lens 19 is situated directly in front of the roof reflector 14. If the surfaces of 20,21,22 are of appropriate shape, radiation transmitted through the reflector lens 19 will be focused. Incoming radiation 4, having the correct direction of polarisation, is transmitted through the reflector lens 19 and suffers no deviation while outgoing radiation 4' is focused directly to the receiver 6.

[0043] When the polarising roof reflector 14 is employed, the beam of radiation incident on the rotating disc 1 undergoes a considerable displacement along the length of the rotating disc 1. Referring to Figure 9, it is possible to replace the single roof reflector 14 with a series of roof reflectors 25 of smaller dimension so that upon reflection from the rotating disc 1 radiation is displaced by a reduced amount (the path of radiation is not shown for clarity), therefore reducing the size of the scanning apparatus still further. Again, the reflector lens 19 may be used to focus outgoing radiation 4' directly to the receiver 6.

[0044] The rotating disc 1 in Figure 9 may be slightly concave. In this case, it is possible to achieve the near linear open scan pattern shown in Figure 10. This open scan pattern enables the number of television lines obtained with the scan pattern in Figure 2(b) to be doubled. For example, for a detector array comprising a number of detector elements separated by a pitch distance, *d*, matching the width, *w*, of the open scan pattern to half of the detector pitch, *d*, enables an interlaced pattern to be obtained. Hence the maximum spatial frequency performance may be achieved. This is analogous to the microscan technique used in infrared imaging [*D.J. Bradley and P.N. J. Denis, "Sampling effects in HgCdTe focal plane arrays in IR technology and applications" (Ed. L. R. Baker and A. Mason), Proc. SPIE vol 590 pp 53-60 (1985)*].

[0045] The use of multiple roof reflectors in the arrangement of Figure 9 can introduce phase changes which impair the spatial resolution of the imager. It may therefore be preferable to sacrifice the benefit of the reduced size of the apparatus in Figure 8 and to use only a single roof reflector, as shown in Figure 8. However, the configuration shown in Figure 8 can lead to pupil wander due to the displacement of an incoming beam 4 by the disc 1 and the roof reflector 15a,15b arrangement and therefore the effective pupil area of the system is reduced.

[0046] The apparatus may also be configured to provide a conical scanning system, rather than a raster scan. One configuration for achieving this is shown in Figure 11. This arrangement provides advantages over the apparatus shown in Figure 8 in that it is more compact and does not give rise to pupil wander. It also has a much improved spatial resolution over the apparatus of Figure 9.

[0047] The arrangement shown in Figure 11 comprises a detector array 30 having a number of detector elements 31, a reflector lens 19, and a rotating plate or disc 1. The disc 1 typically rotates about an axis passing through its centre at an angle of inclination of a few degrees to the normal to the axis, say 5°, as described previously. The reflector lens 19 has the structure described with reference to Figure 7 and comprises a polarising reflector element 20 (e.g. a vertical wire grid), a 45° Faraday rotator 21 and a polarising reflector element 22 (e.g. a 45° wire grid). The elements may have curved surfaces as shown in Figure 7. Alternatively, one or two of the elements may have a plane surface.

[0048] The operation of the reflector lens 19 is such that incident radiation 4 of one polarisation, in this case horizontal polarisation, passes through the lens arrangement without any focussing effect, as described previously, whereas on passing through the lens for a second time, from the opposite direction, it is focussed.

[0049] A single detector element 32 in the detector array 30 traces out a circular scan pattern. As the detector elements 31 lie adjacent to one another, the image formed is a series of displaced circles, as shown in Figure 12. As the reflector lens 19 can be placed between the detector array 30 and the rotatable disc 1 the scanning system is compact. In conventional arrangements, scanning optics have to be located apart from the focussing components which can make such systems inconveniently large.

[0050] In a particular embodiment of the arrangement shown in Figure 11, the polarising element 20 may have a substantially flat surface and the polarising element 22 may have a substantially spherical surface, this spherical surface having a radius of curvature R and thus a focus at a distance R/2 from the spherical surface. In this embodiment, the elements 31 of the detector array 30 form part of a spherical surface having half the radius of curvature (R/2) of polarising element 22 and being concentric with it. The detector elements 31 may be fed by horns in which case the apparatus is arranged such that the focus (i.e. at R/2) of polarising element 22 is located within the dimension of the horn. As a further refinement, a corrector plate may be placed between the rotatable disc 1 and the polarising element 22 to remove spherical aberrations from the image formed at the detector array 30.

[0051] In any of the arrangements shown in Figures 8, 9 or 11 two or more reflector lenses 19 may be included in series.

[0052] For some applications the conical scanning apparatus shown in Figure 11 may be preferred over the Figure 8 and 9 configurations, even at the expense of the more complex conical scan pattern. In practice, the preferred configuration of the apparatus will depend on the particular application for which it is to be used.

[0053] Whilst the scanning apparatus has been described with reference to millimetre wave imaging in particular, it may also be applicable to other radiometry systems. The technique of transmitted high powered radio waves to a scene and analysing radiation transmitted back to a radar receiver is well known. For example, by scanning radiation transmitted back to the radar receiver using the scanning apparatus, the need for large, moveable receiver elements employed in radar systems is removed. The input radiation to the scanning apparatus is therefore the radiation reflected from the scene which is transmitted to the scene by the radar transmitter. For the purpose of this specification the phrase "radiation from a scene" shall therefore be taken to mean radiation emitted by, reflected from or transmitted from a scene.

Claims

1. A reflector lens (19) comprising;
   a first polarising surface (20) having a first polarisation axis (23), for selectively transmitting radiation having a polarisation parallel to the first polarisation axis (23) and selectively reflecting radiation having a polarisation orthogonal to the first polarisation axis (23),
   a second surface (21) for rotating the direction of polarisation of radiation through substantially 45° and
   a third polarising surface (22) having a third polarisation axis (24) for selectively reflecting radiation having a polarisation orthogonal to the third polarisation axis (24) and selectively transmitting radiation having a polarisation parallel to the third polarisation axis (24),
   wherein the third polarisation axis (24) makes an angle of substantially 45° with the first polarisation axis (23).

2. The reflector lens of claim 1, wherein at least one of the first (20), second (21) or third (22) surfaces has a curved surface.

3. The reflector lens of claim 1 or claim 2 wherein incident radiation passing through the reflector lens in one direction is focussed by the lens but radiation passing through the reflector lens in the other direction experiences no focussing effect.

Fig.1.
(PRIOR ART)

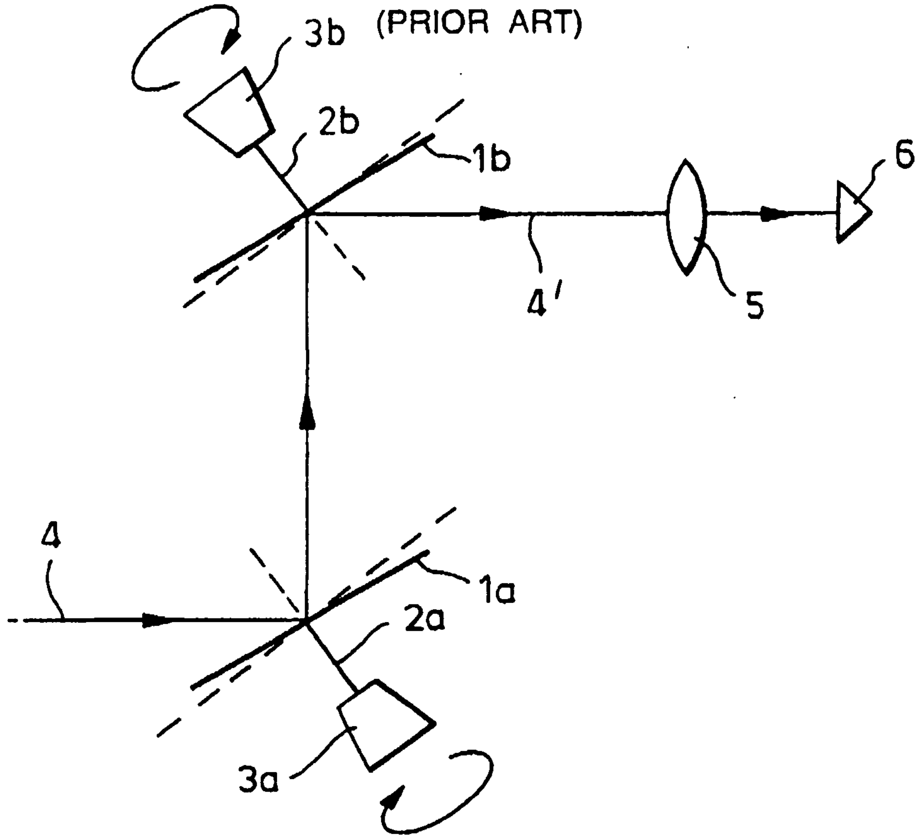


Fig.2(a).

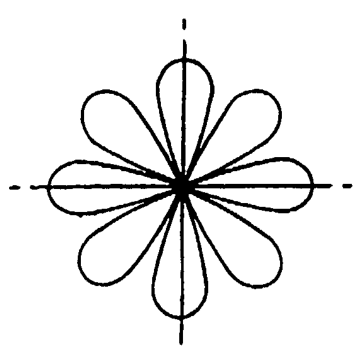


Fig.2(b).

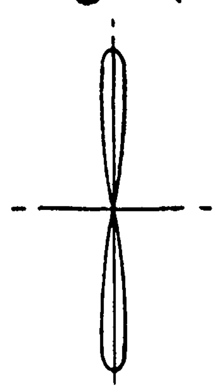


Fig.3.

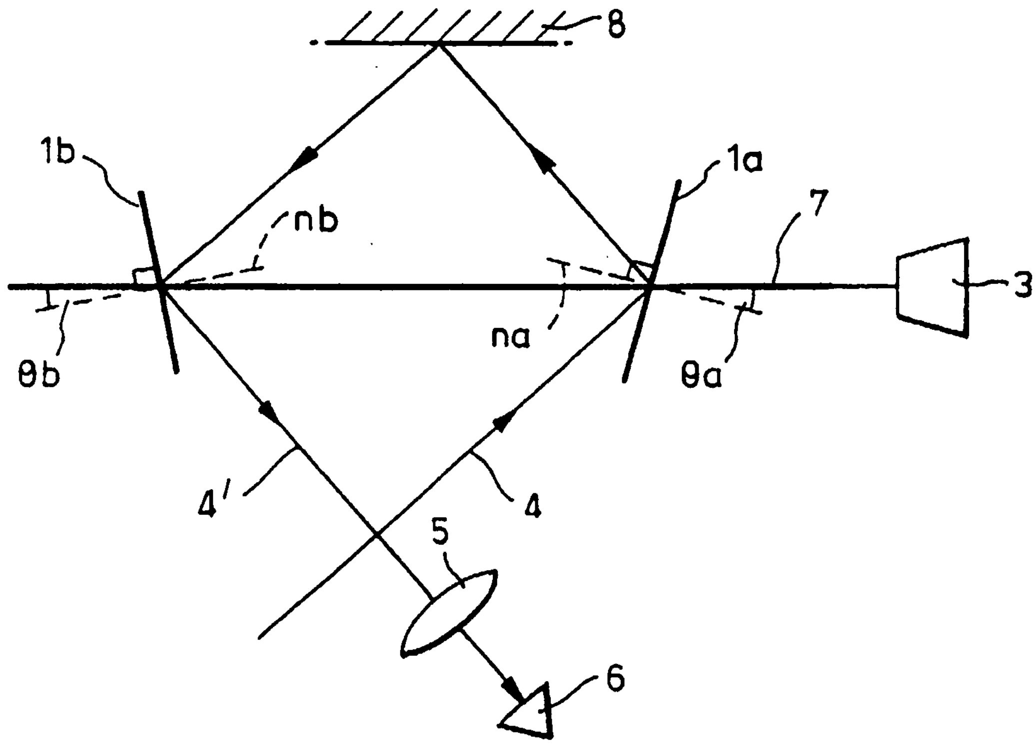


Fig.4.

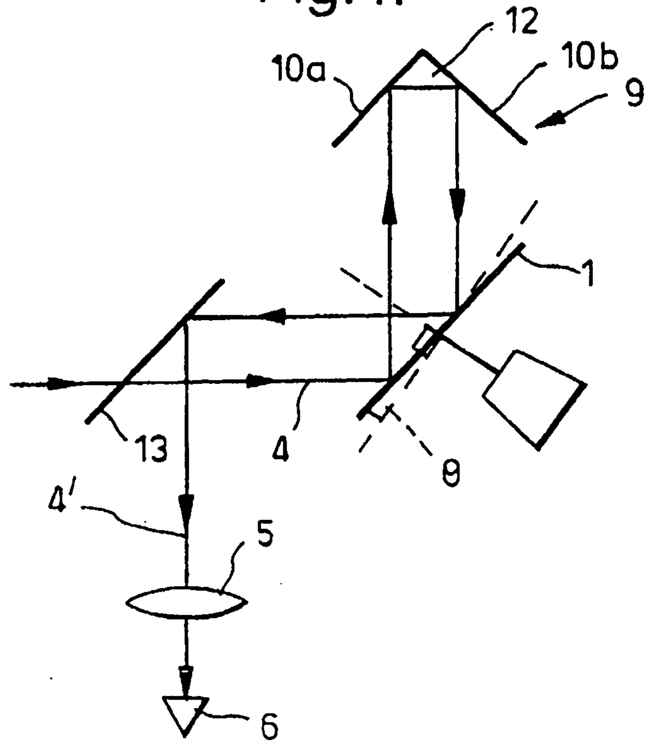


Fig.5.

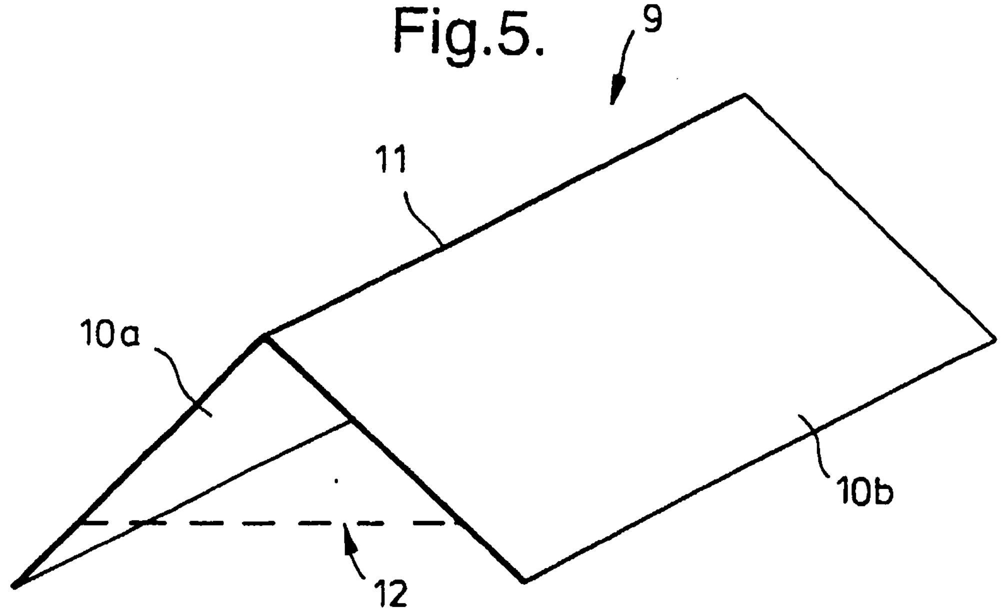


Fig.6.

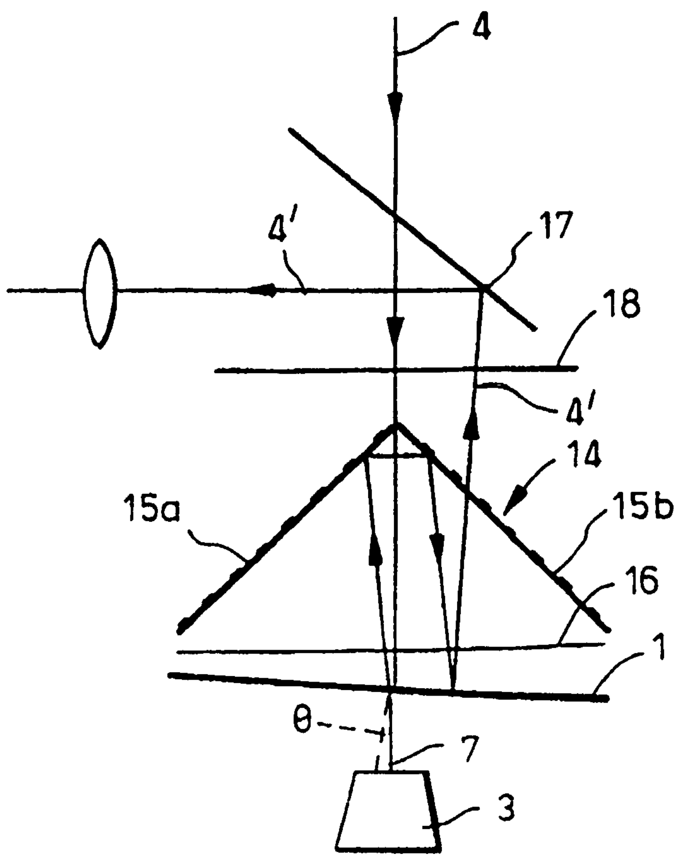


Fig.7.

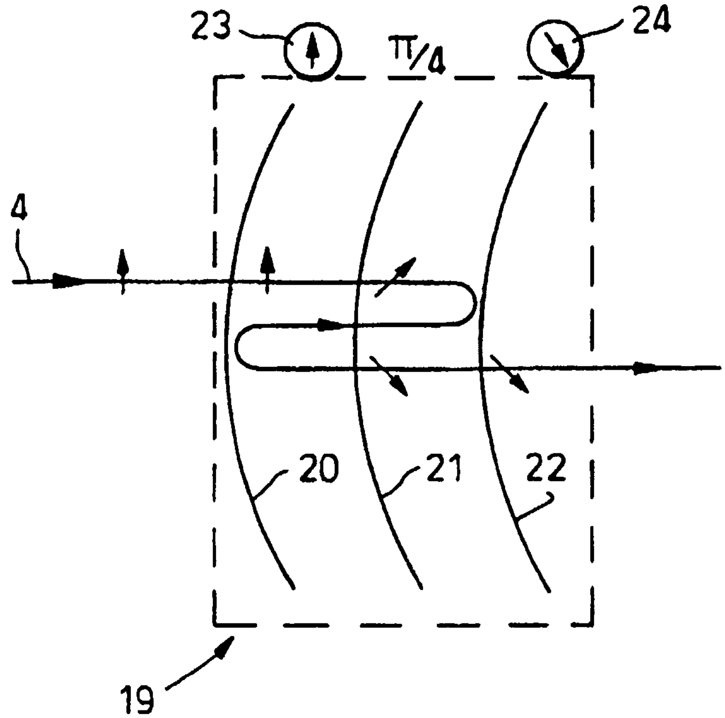


Fig.8.

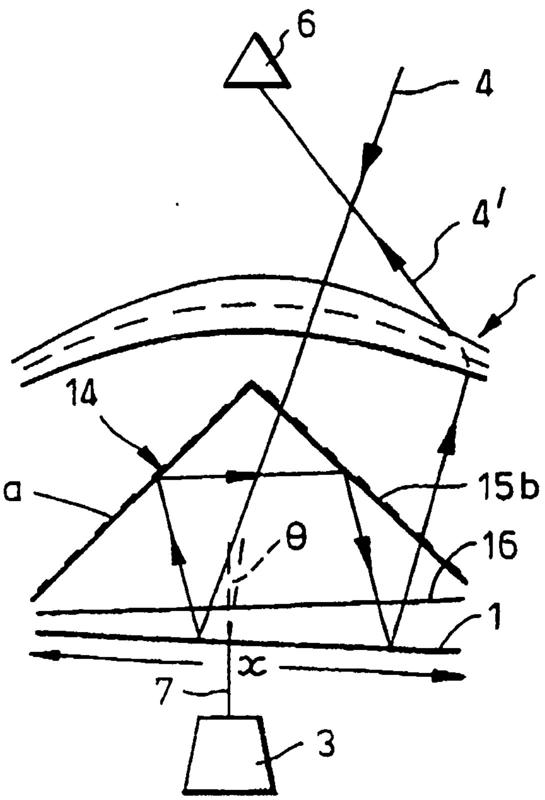


Fig.9.

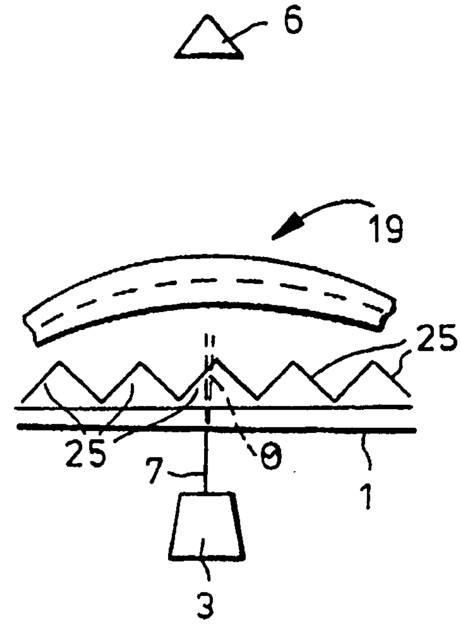


Fig.10.

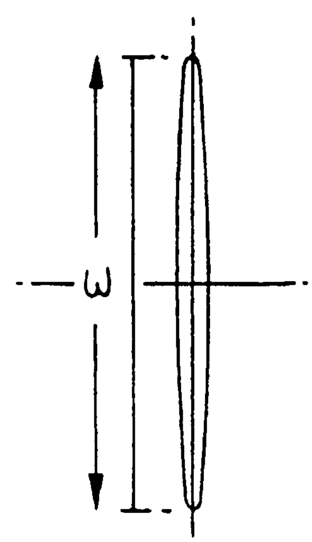


Fig.11.

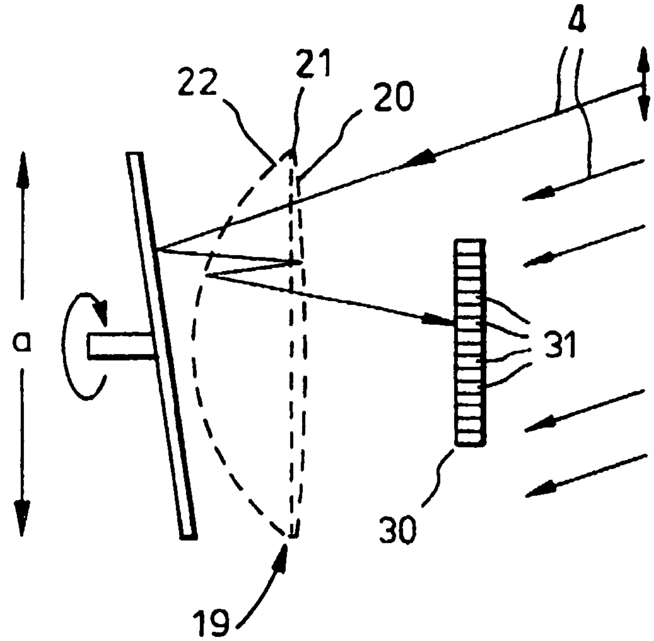

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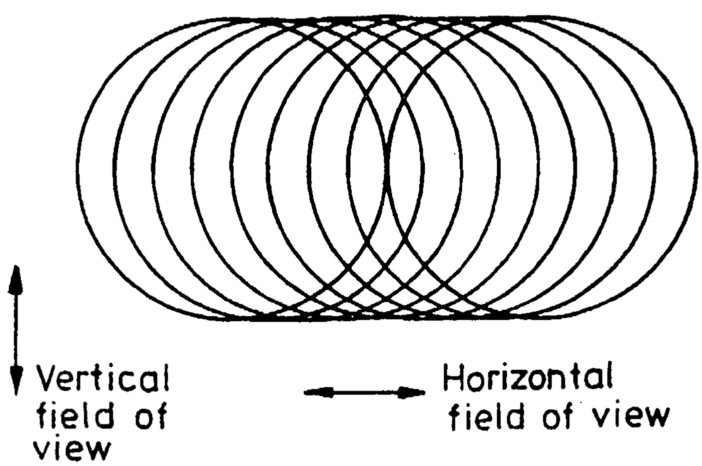
Fig.12.


Vertical field of view
Horizontal field of view

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EUROPEAN SEARCH REPORT

Application Number
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G01S
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H04N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	22 July 2003	Danielidis, S

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